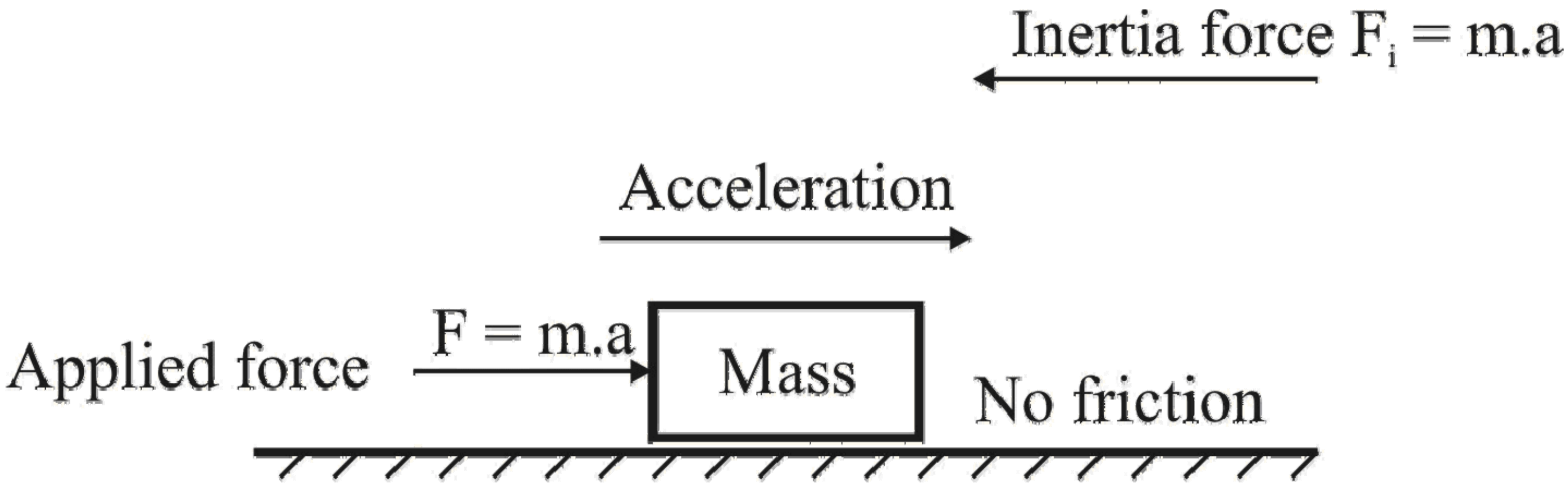
Introduction

- If an instrument output signal is to follow a rapidly fluctuating input signal closely; the instrument should posses a good dynamic response.
- the instrument should be capable of following the fluctuations no matter how fast they occur.
- In dynamic measurements the experimenter is concerned with the amplitude of the signal at any instant of time and therefore his instrument must be capable of fast responding to the amplitude variations.

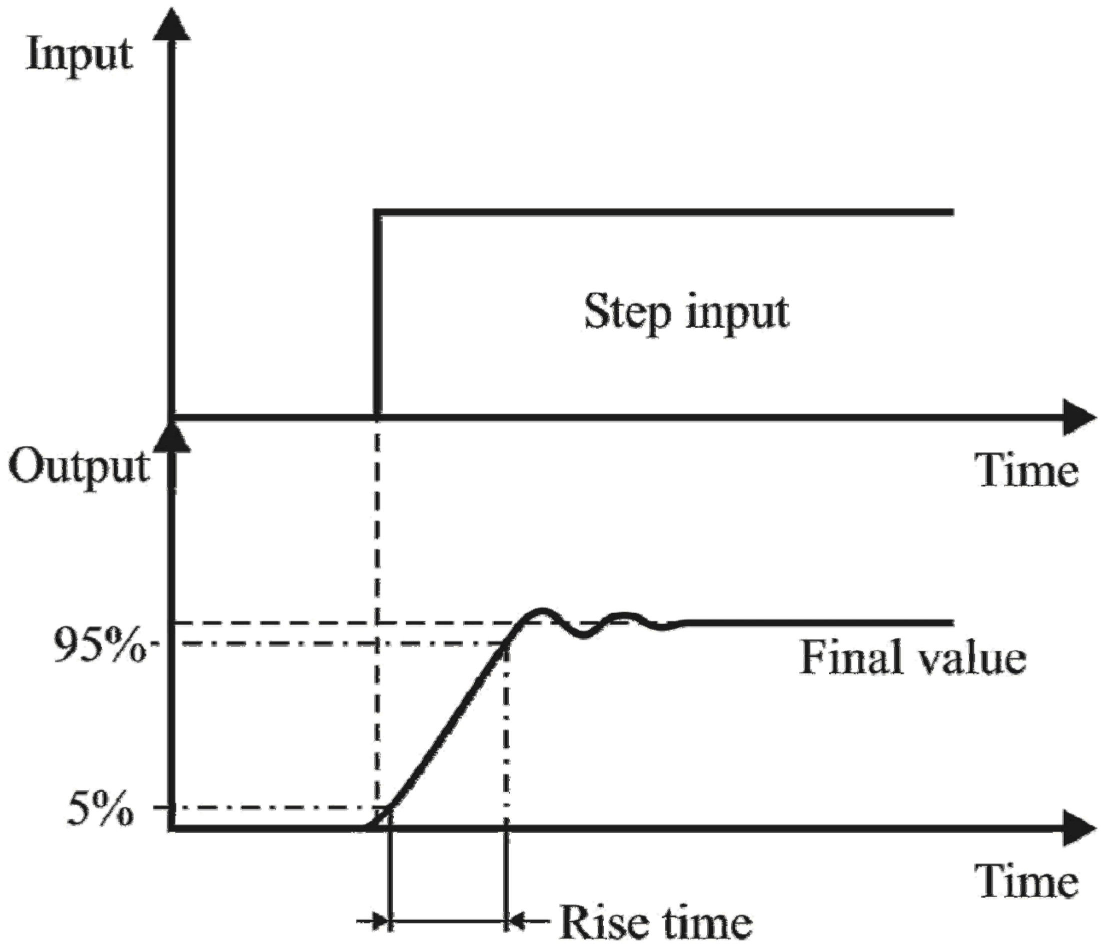
System Response and Measurement Lag



- In dynamic measurement the input signal changes and so the measuring system will be unable to follow accurately these variations due to the natural inertia of the system.
- The inability of the measuring system to follow the changes of the output signal results in a time delay in the output signal and this delay is known as the measurement lag.

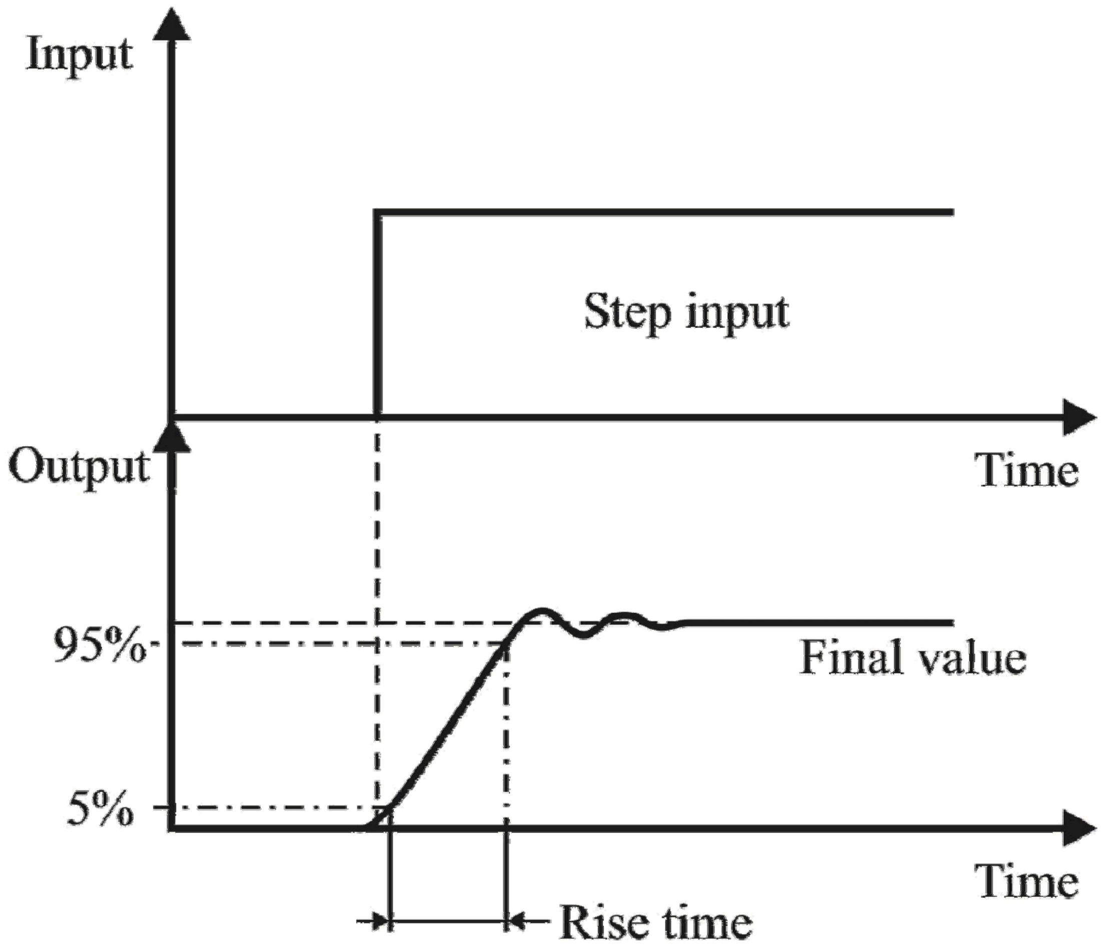
Measurement Lag

- If an abrupt or sudden change is applied to a measuring instrument, then a delay in the output response of the system will occur.
- The sudden change in the input signal is normally known as a step input.
- In electronic instruments the step input is obtained by applying a square wave pulses from an oscillator.



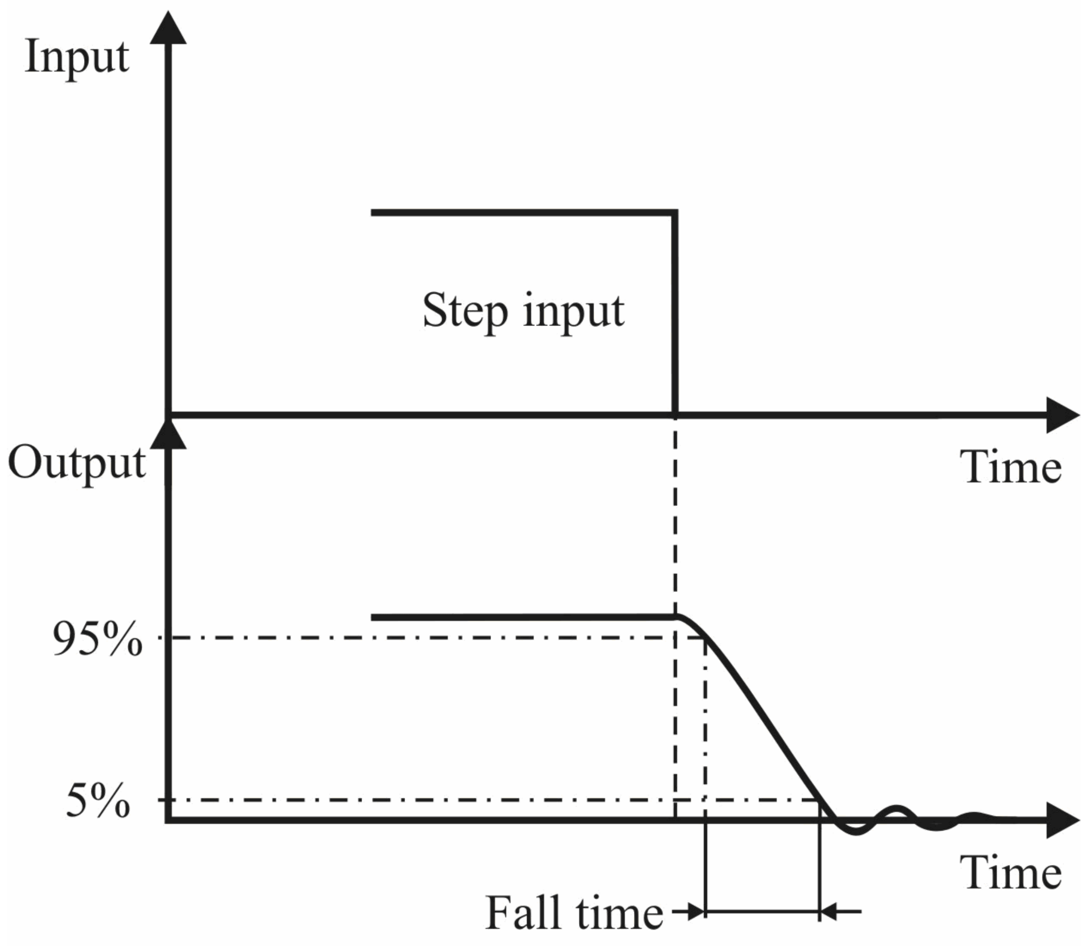
Rise Time

- The rise time is usually defined as the time taken for a system to change from 5% to 95% of its final value in initial part of the curve The sudden change in the input signal is normally known as a step input.
- Sometimes changes from 10% to 90% are used and in this case one has to state that his rise time is based on 10% to 90% changes.



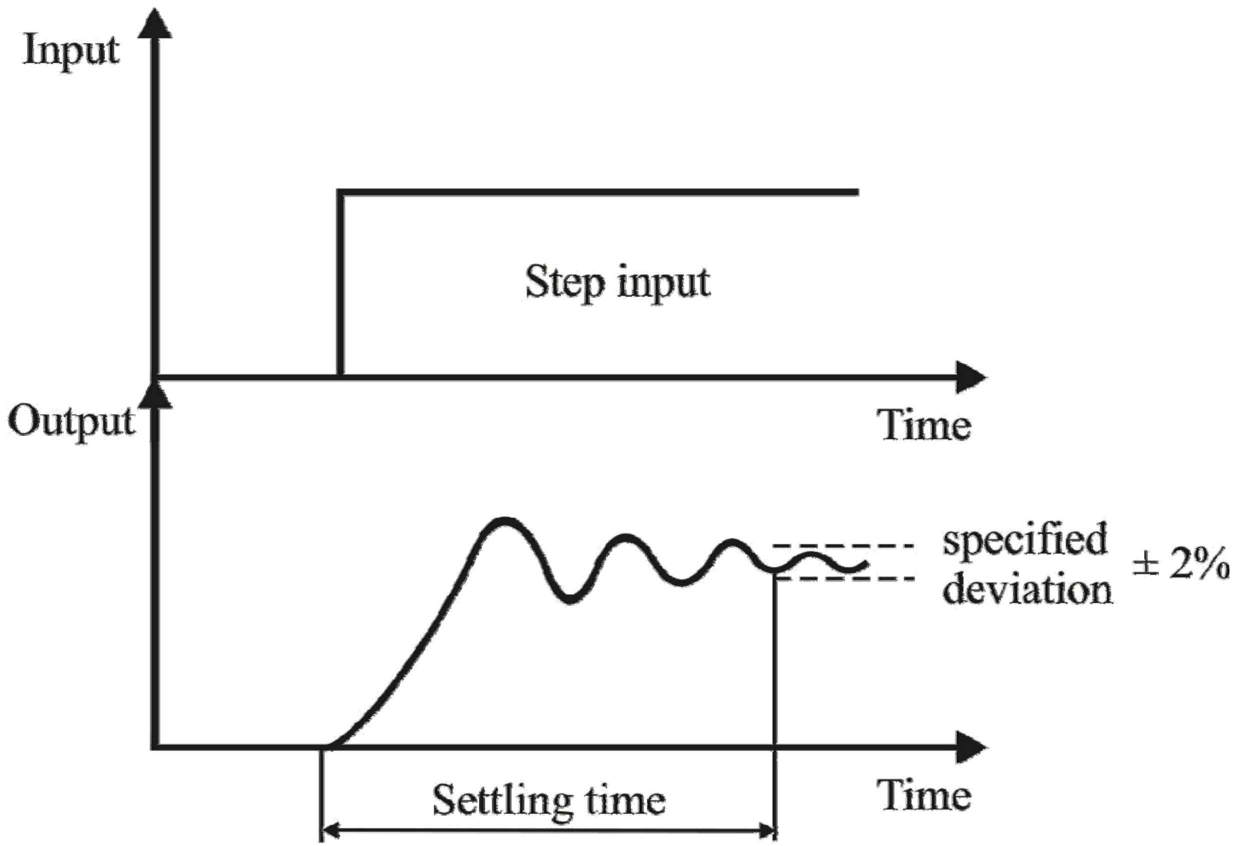
Fall Time

- the time taken for a system to change from 95% to 5% in the initial part of the curve.

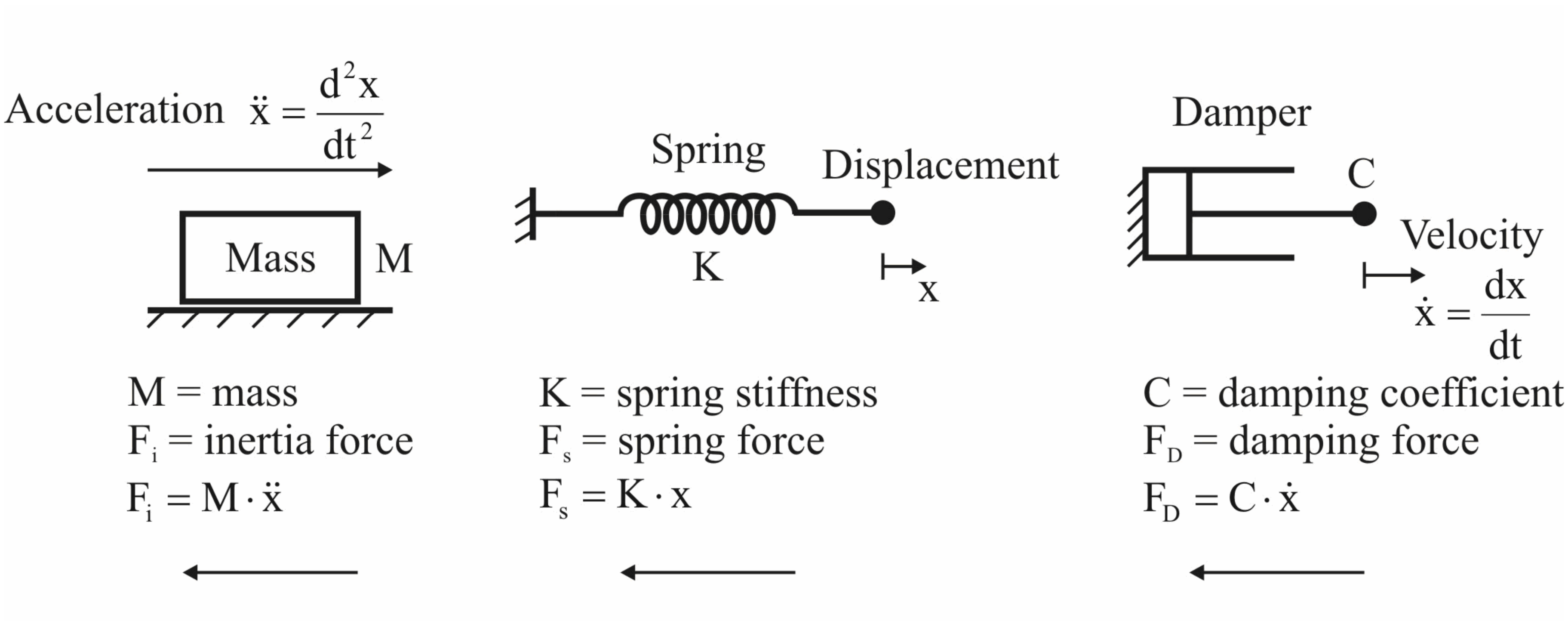


Settling Time

The Settling Time: is defined as the time taken for the final value of an instrument **to attain, and remain** within, a specified deviation (typically ±2%) from its desired value **after an abrupt change in the measured quantity.**



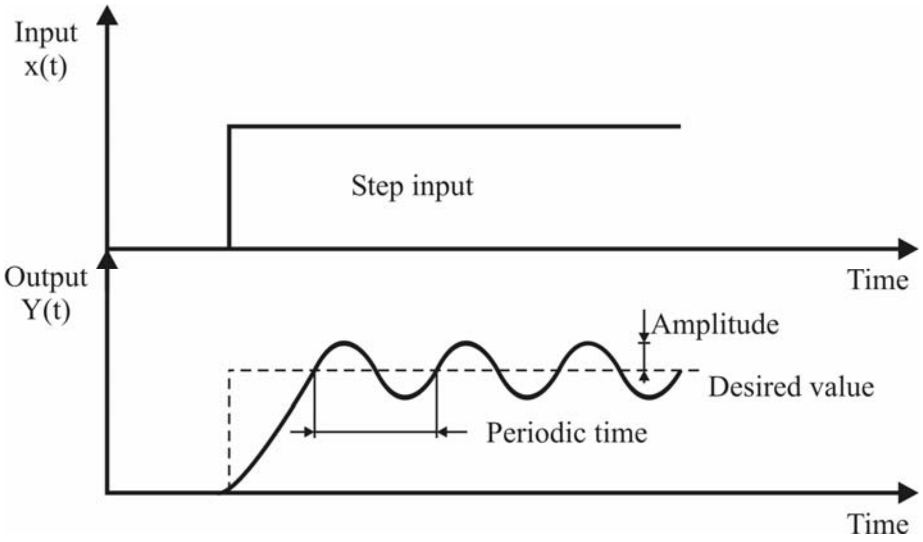
Forces on Mechanical Elements

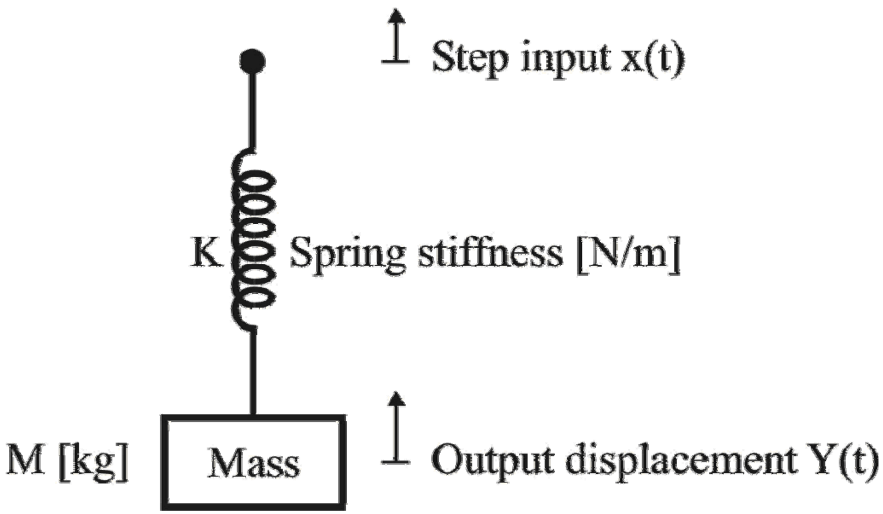


Spring-Mass System

A step input causes the system to oscillate with a simple harmonic motion

$$\text{Periodic Time} = \frac{2\pi}{\omega_n} \qquad \text{Natural frequency } \omega_n = \sqrt{\frac{K}{M}}$$





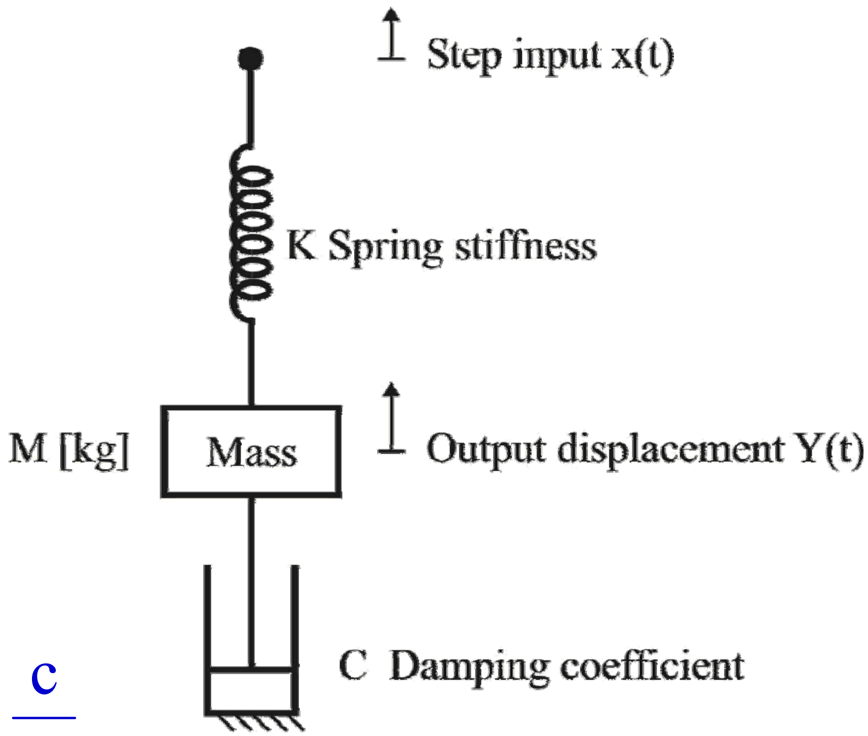
Spring-Mass-Damper System (1)

The damper restores equilibrium

$$\text{Periodic Time} = \frac{2\pi}{\omega_d} = \frac{2\pi}{\omega_n\sqrt{\left(1-\xi^2\right)}}$$

$$\text{Natural frequency } \omega_n = \sqrt{\frac{K}{M}}$$

$$\xi = \frac{\text{Damping Coefficient}}{\text{Critical Damping Coefficient}} = \frac{c}{c_c}$$



Spring-Mass-Damper System (1)

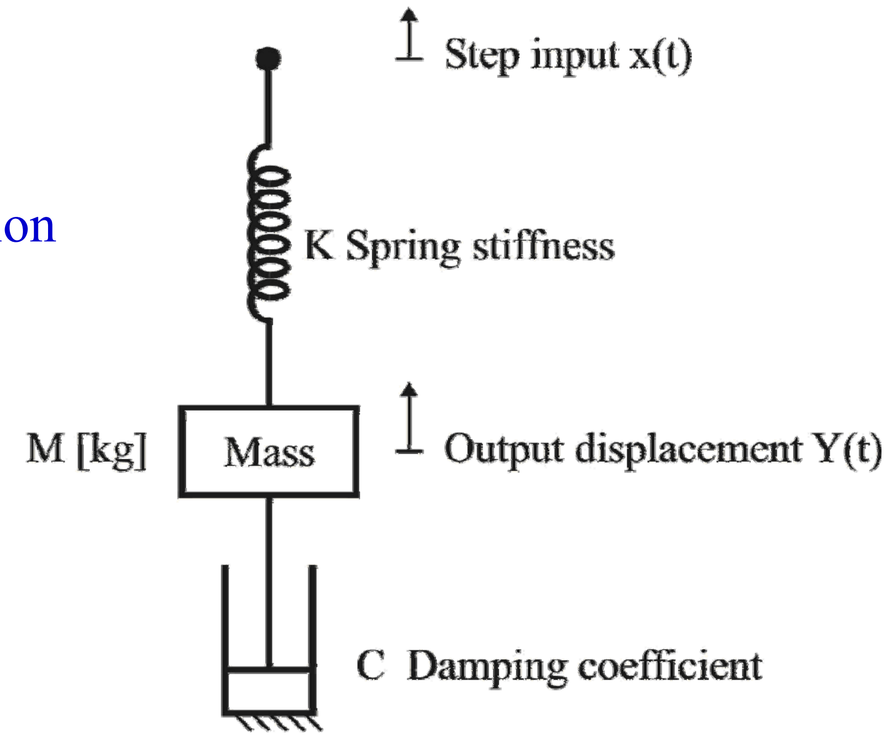
The critical damping coefficient is the damping coefficient for just no overshoot

$\xi = 0$ undamped, simple harmonic motion

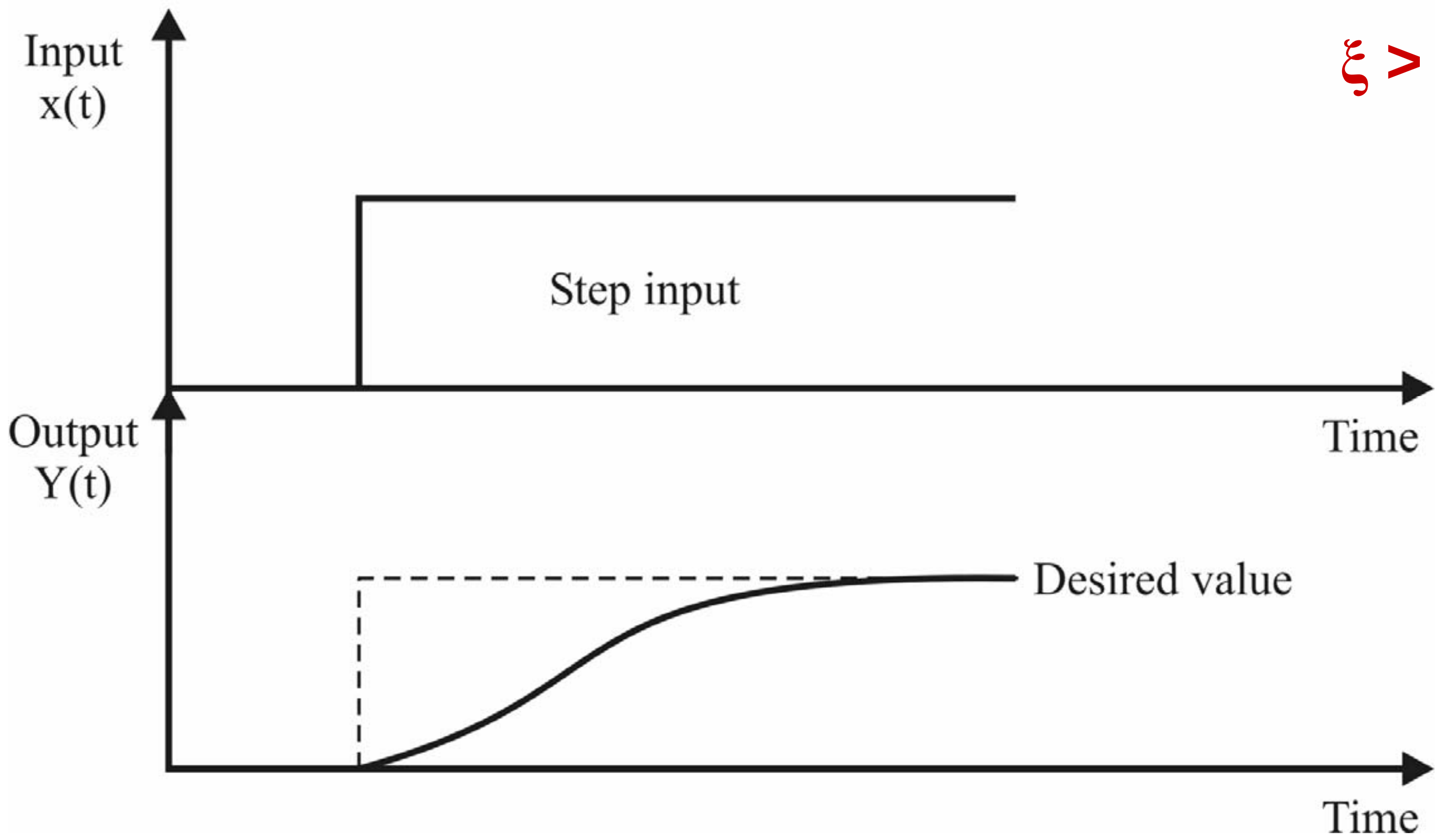
$\xi = 1$ critical damping

$\xi > 1$ over-damped

$\xi < 1$ under-damped



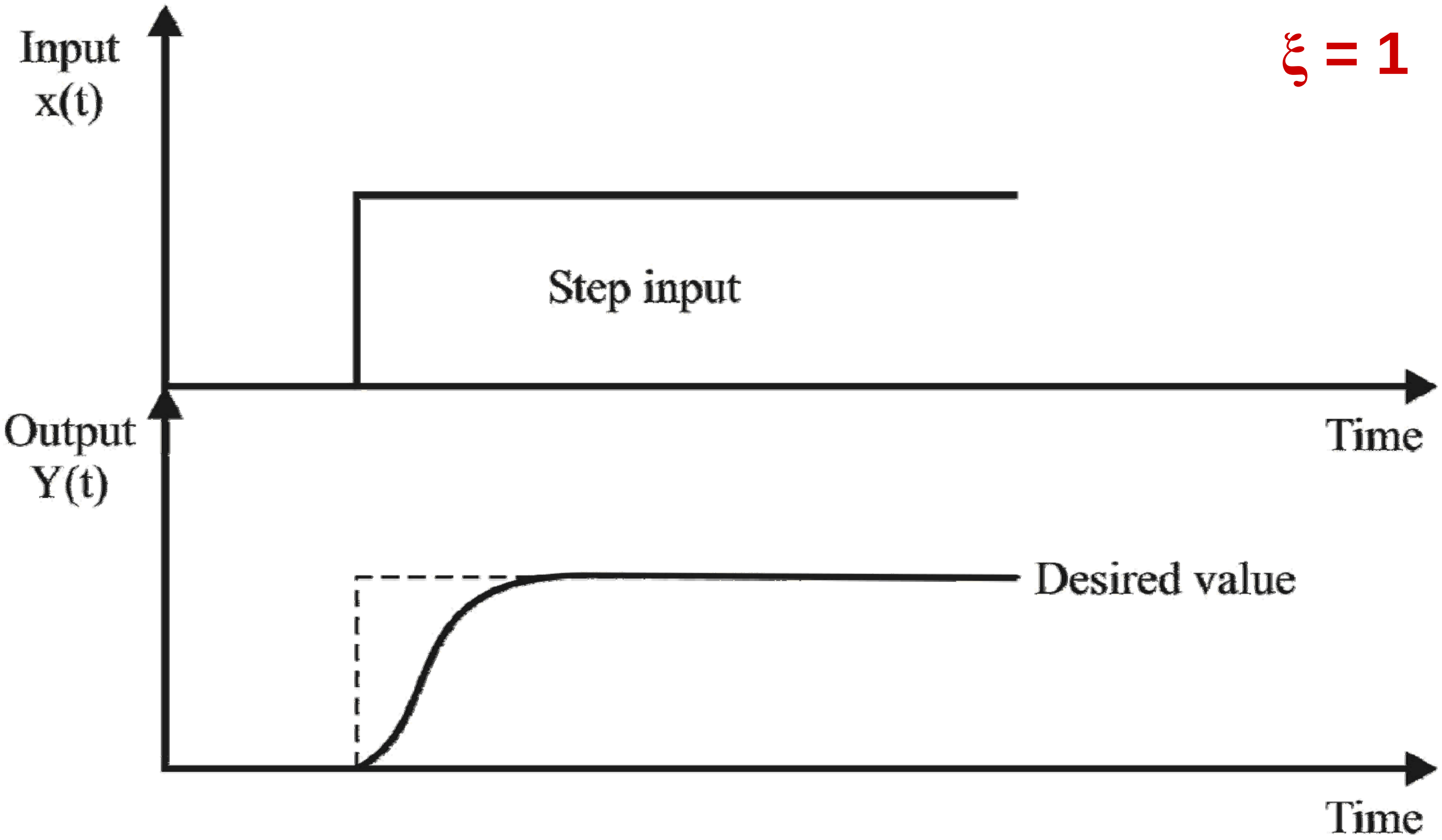
Over Damped System



$\xi > 1$

Critically Damped System

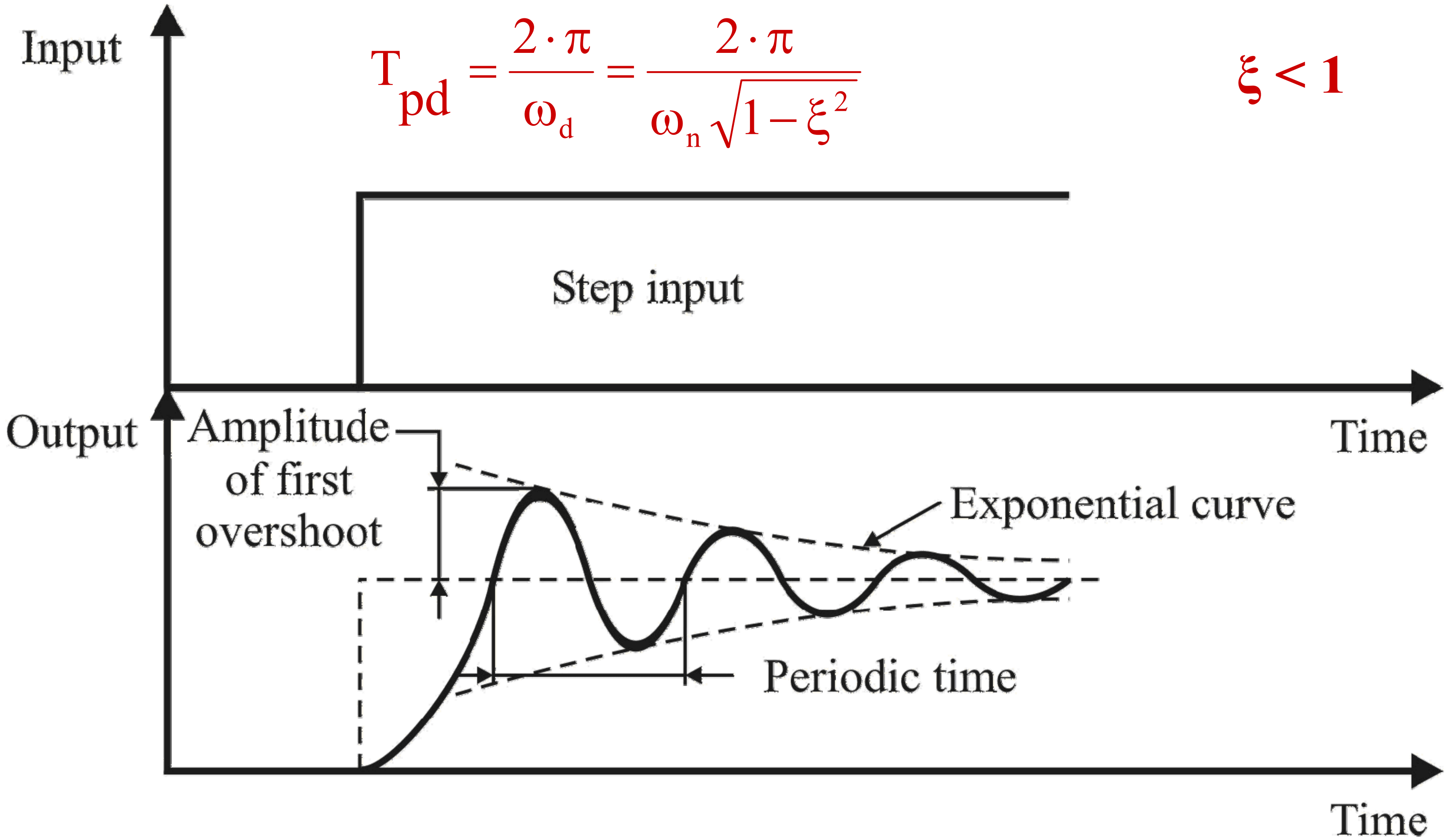
$\xi = 1$



Under Damped System

$$T_{pd} = \frac{2 \cdot \pi}{\omega_d} = \frac{2 \cdot \pi}{\omega_n \sqrt{1-\xi^2}}$$

$$\xi < 1$$




Thank You!